Managing Uncertainty in Generation, Inventory and Revenue

January 23, 2011 AMS Meeting

AMS SHORT COURSE:
HYDROLOGIC PREDICTION AND VERIFICATION TECHNIQUES
WITH A FOCUS ON WATER SUPPLY

Introduction to the Federal Columbia River Power System and the Bonneville Power Administration

Federal Columbia River Power System

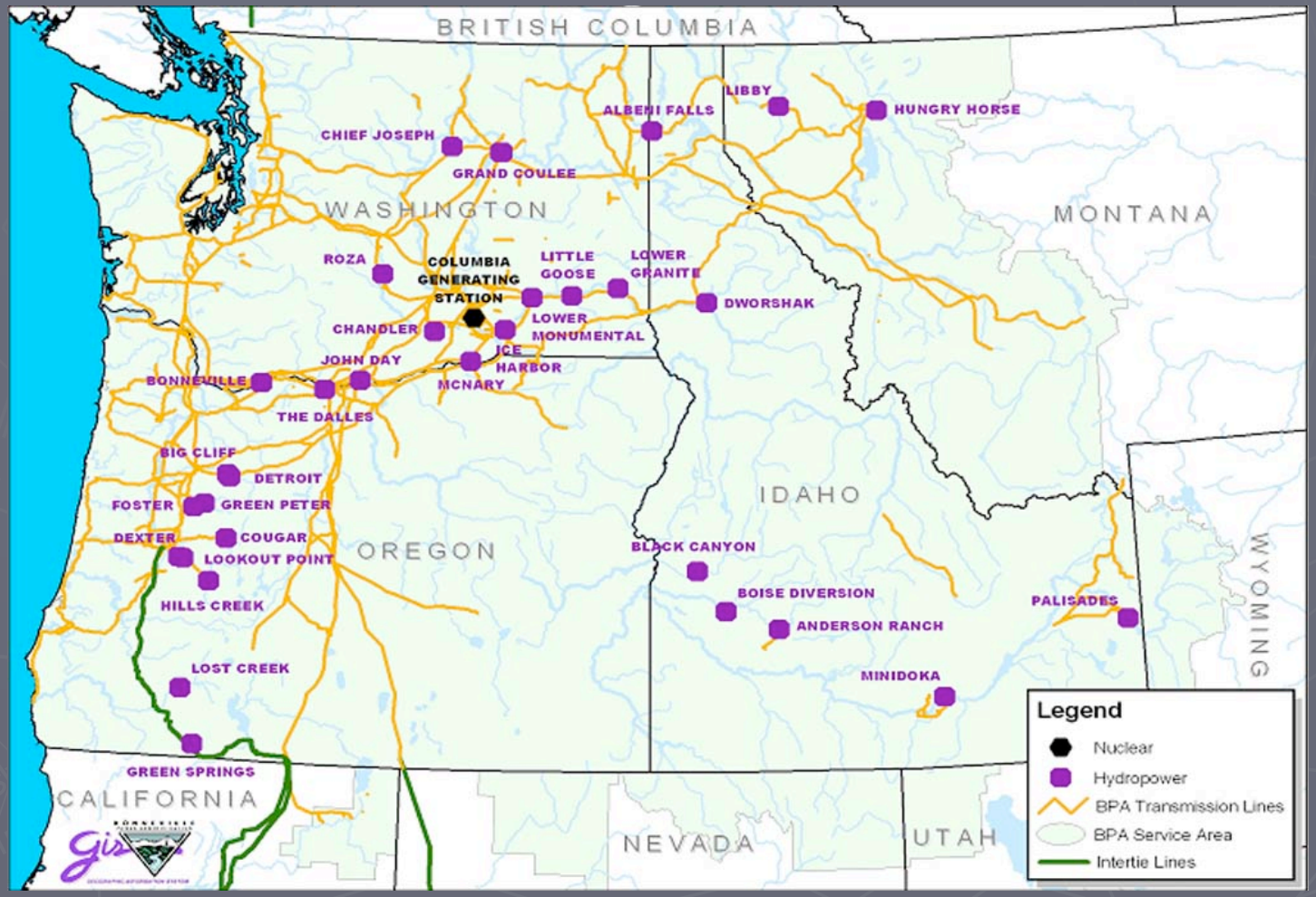
- The key federal agencies:
  - The US Army Corps of Engineers
  - The Bureau of Reclamation
  - The Bonneville Power Administration
- The major physical assets:
  - 31 federal hydro-electric power plants
  - Columbia Generating Station (Nuclear Power Plant)
  - The federal high voltage transmission system

Federal Columbia River Power System

- The US Army Corps of Engineers and the Bureau of Reclamation operate the federal dams for multiple public purposes:
  - Flood Control
  - Navigation
  - Fish protection operations (Endangered Species Act, Clean Water Act)
  - Recreation
  - Power production

- BPA's Role
  - Markets the power produced from the federal dams within the constraints and requirements for other river purposes
  - Primary high-voltage transmission provider in the Columbia River Basin

Federal Columbia River Power System



Federal Columbia River Power System

FCRPS Annual Operations Cycle

- **July – August**: Draft the system to augment flows supporting the downstream migration of juvenile fish.
- **September – October**: Operate the system to prepare for Fall fisheries operations at Lake Roosevelt, Vernita Bar, and downstream of Bonneville.
- **November – December**: Provide hydraulic conditions for Chum, Fall Chinook, and Kokanee spawning. Meet Winter flood control requirements at Libby and Dworshak.
- **January – April**: Draft the system for flood control while supporting protection elevations for Chum and Fall Chinook.
- **May – June**: Refill the system on the Spring freshet.

BPA's Modeling Process

Realizing Uncertainty in Generation and Energy Inventory

BPA's Generation Modeling System

- HYDSIM – A hydraulic simulation model that provides the underlying flow and elevation targets for HOSS, the higher resolution generation shaping model
- HOSS – An hourly operations and scheduling simulator that takes the output from HYDSIM and provides hourly generation shaping for the hydro projects

BPA's Generation Modeling System

- Inputs:
  - Hydraulic objectives
  - Project constraints
  - Streamflow scenarios
  - Hydro unit availabilities
  - Load obligations
- Outputs
  - Generation distributions

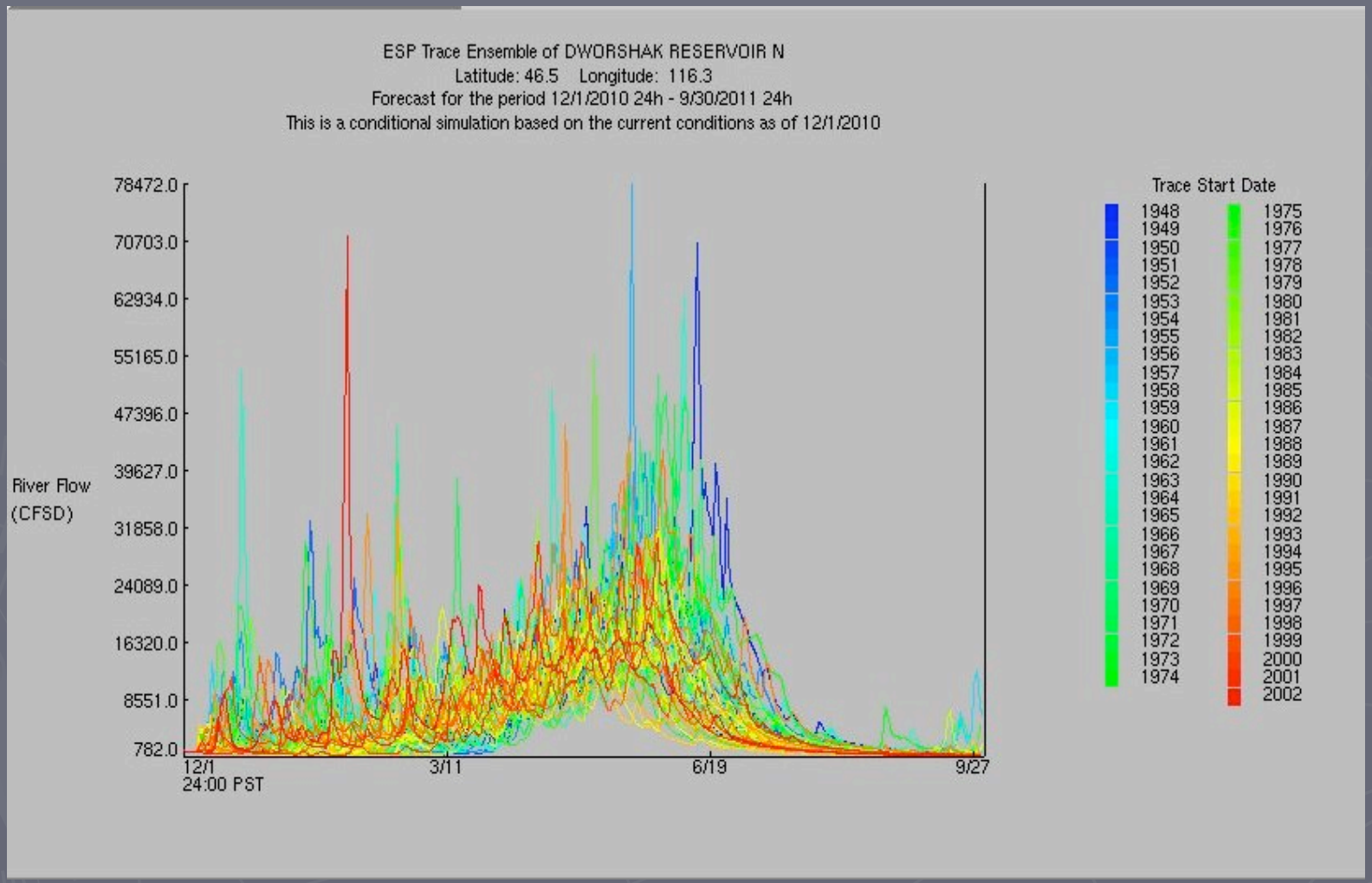
Hydraulic Objectives and Project Constraints

- Hydraulic objectives:
  - Flood control
  - Fisheries operations
  - Navigation requirements
  - Recreational interests
  - Special operations
- Project constraints
  - Physical plant characteristics

Ensemble Streamflow Prediction

- Ensemble of traces initiated with current basin conditions
  - Soil moisture
  - Snowpack
- Perturbed with historical meteorological sequences
- Generates a distribution of possible future streamflow scenarios

Ensemble Streamflow Prediction

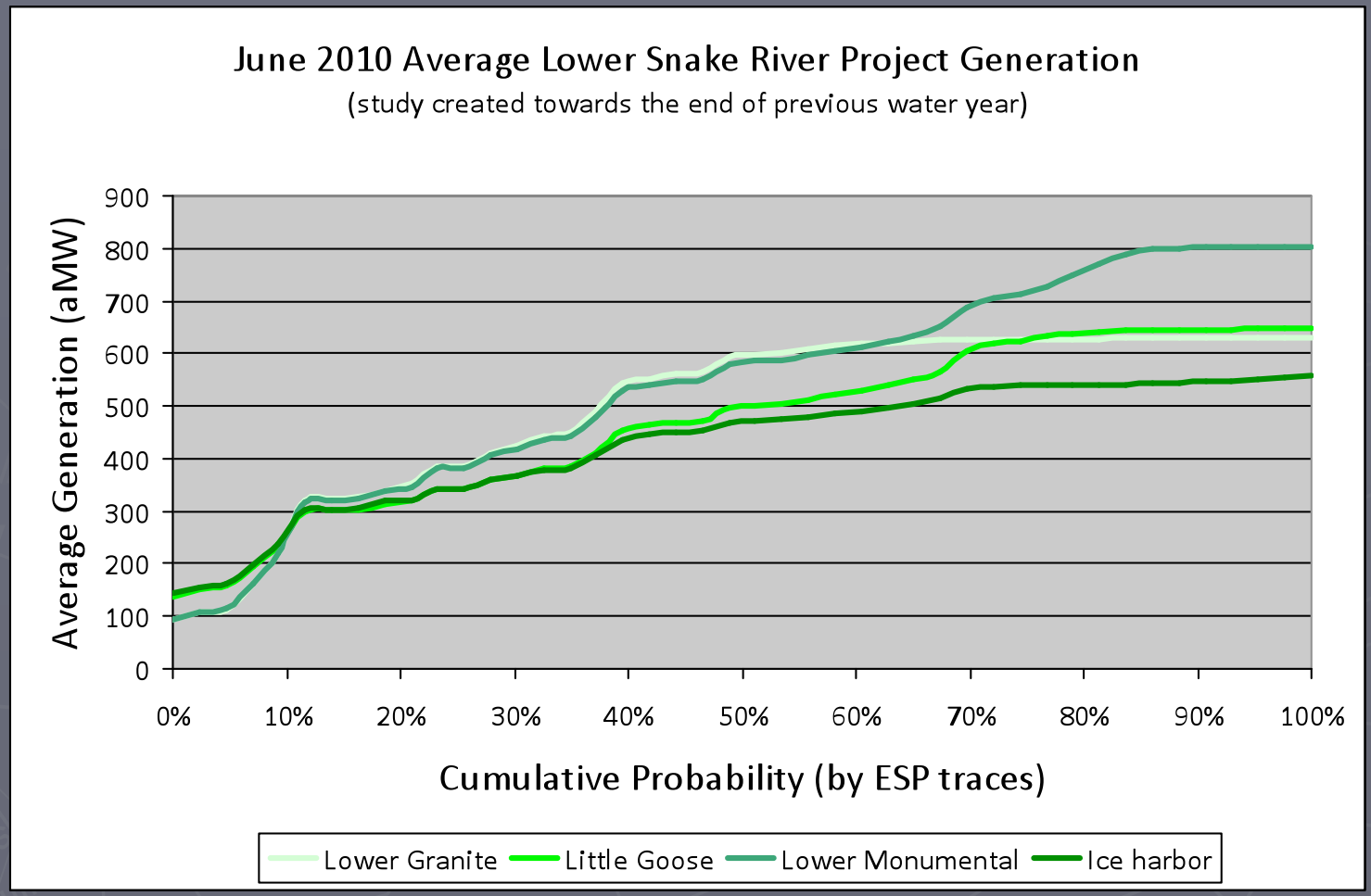


Realizing Uncertainty in Electricity Generation

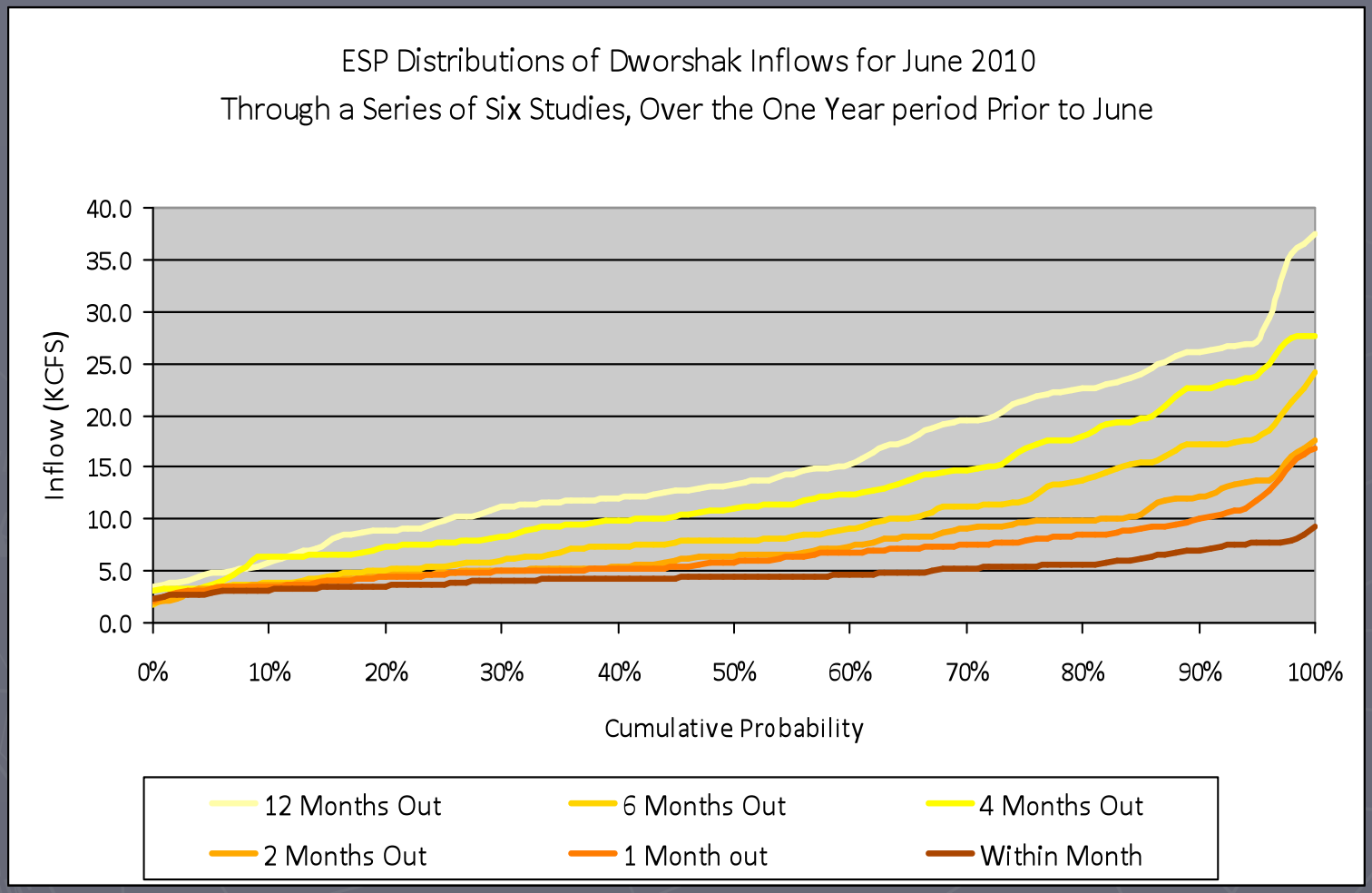
- Given the large amount of uncertainty in streamflows there is often a large range of possible hydro generation

- The following example shows the possible combined lower Snake River generation ranging from as low as 500 aMW to as much as 2,600 aMW in June

Generation Distributions



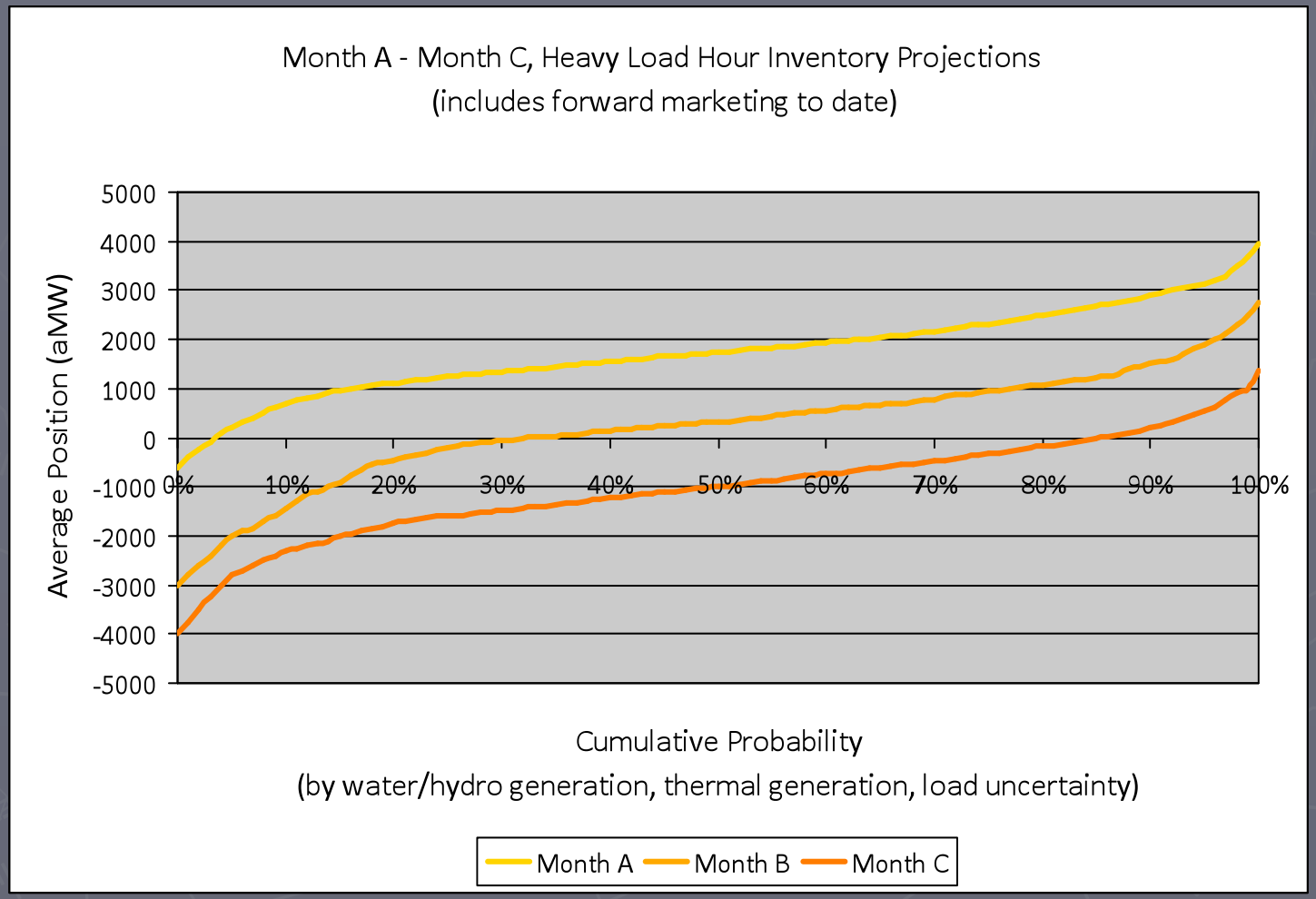
Uncertainty Diminishes Over Time



BPA's Energy Inventory Modeling System

- Inputs:
  - Hydro generation distributions
  - Thermal generation distributions
  - Load obligation distributions
- Outputs
  - Energy inventory distributions

Energy Inventory Distributions



Realizing Uncertainty in Energy Inventory

- Given the large amount of uncertainty in all of the modeling inputs, especially streamflows, there is often a large range of possible energy inventory for any given future time period

- In the previous example:
  - -800 aMW < Month A Inventory < 4,000 aMW
  - -3,000 aMW < Month B Inventory < 2,800 aMW
  - -4,000 aMW < Month C Inventory < 1,300 aMW

Using the Marketplace

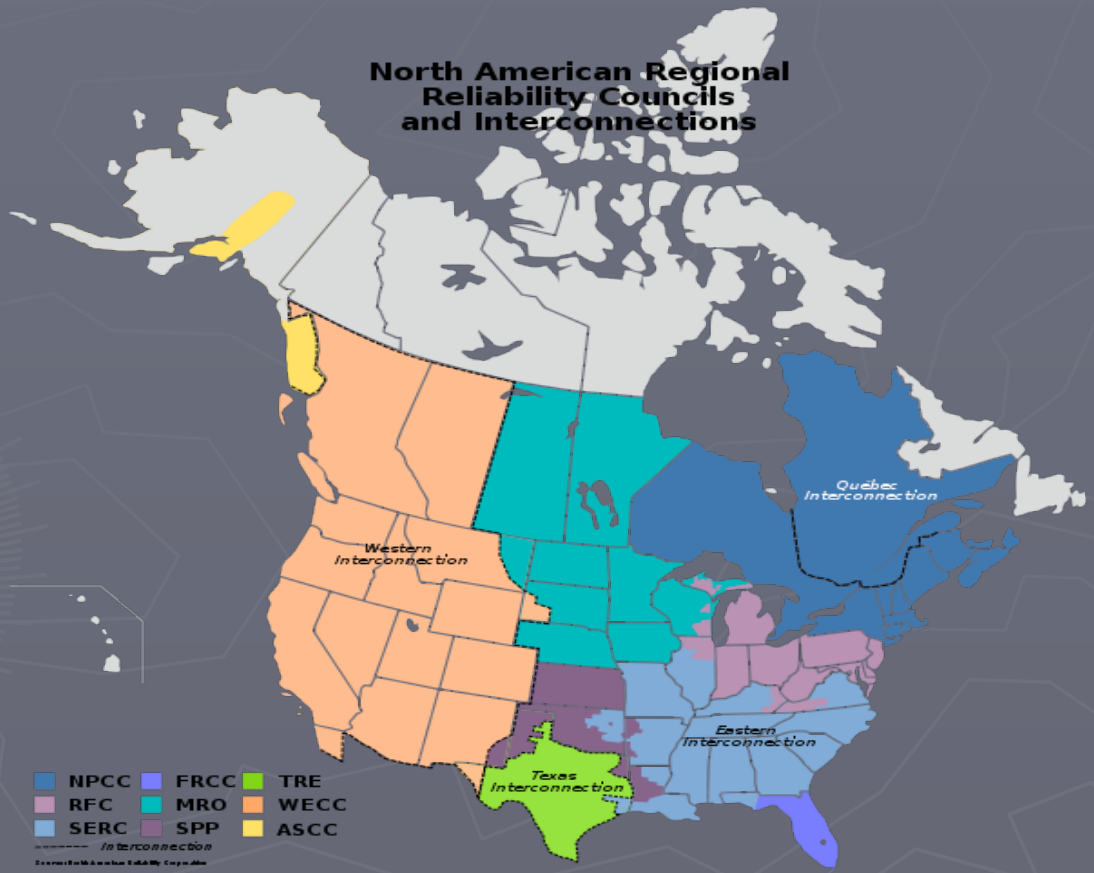
Managing Uncertainty in Energy Inventory and Power Marketing Revenue

The West Power Market

- Electricity is a commodity
- Electricity markets, like other markets, are influenced primarily by supply and demand
- To understand electricity markets one must understand where generation comes from (supply), how much electricity is needed (demand), and how does the electricity get from the generator to the customer (transmission).

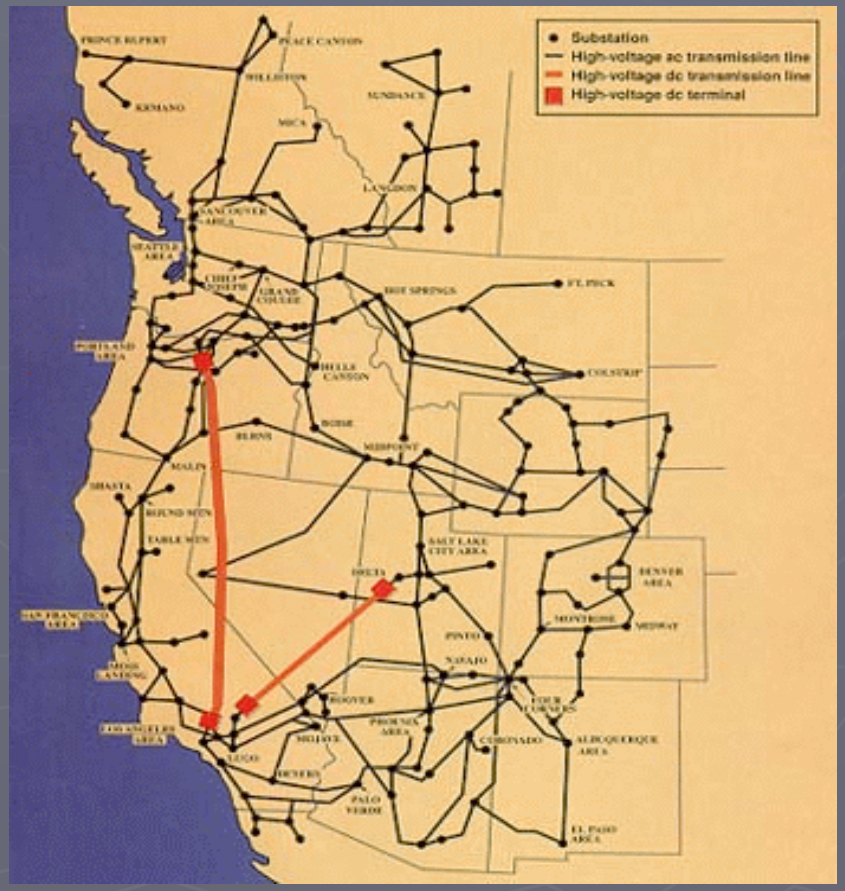
The West Power Market

The Western Interconnection



The West Power Market

The Western Interconnection



The West Power Market

How is electricity generated?

- Thermal Power Plants
  - Coal
  - Natural Gas
  - Nuclear
  - Biomass
- Hydro Power
- Wind Power

The West Power Market

How is electricity consumed?

- Residential customers
  (e.g. light bulbs and toaster ovens)
- Commercial sector
  (e.g. businesses)
- Industrial sector
  (e.g. manufacturing, metal smelting)

The West Power Market

Who trades power in the West?

- Utilities
- Power marketers
- Investment banks
- Oil companies
- Hedge funds

The West Power Market

What are the products?

- Physical power
  - Yearly strips
  - Quarterly pieces
  - Monthly pieces
  - Balance of month pieces
  - Daily and hourly products
- Future options to buy or sell power

The West Power Market

How are the various products traded?

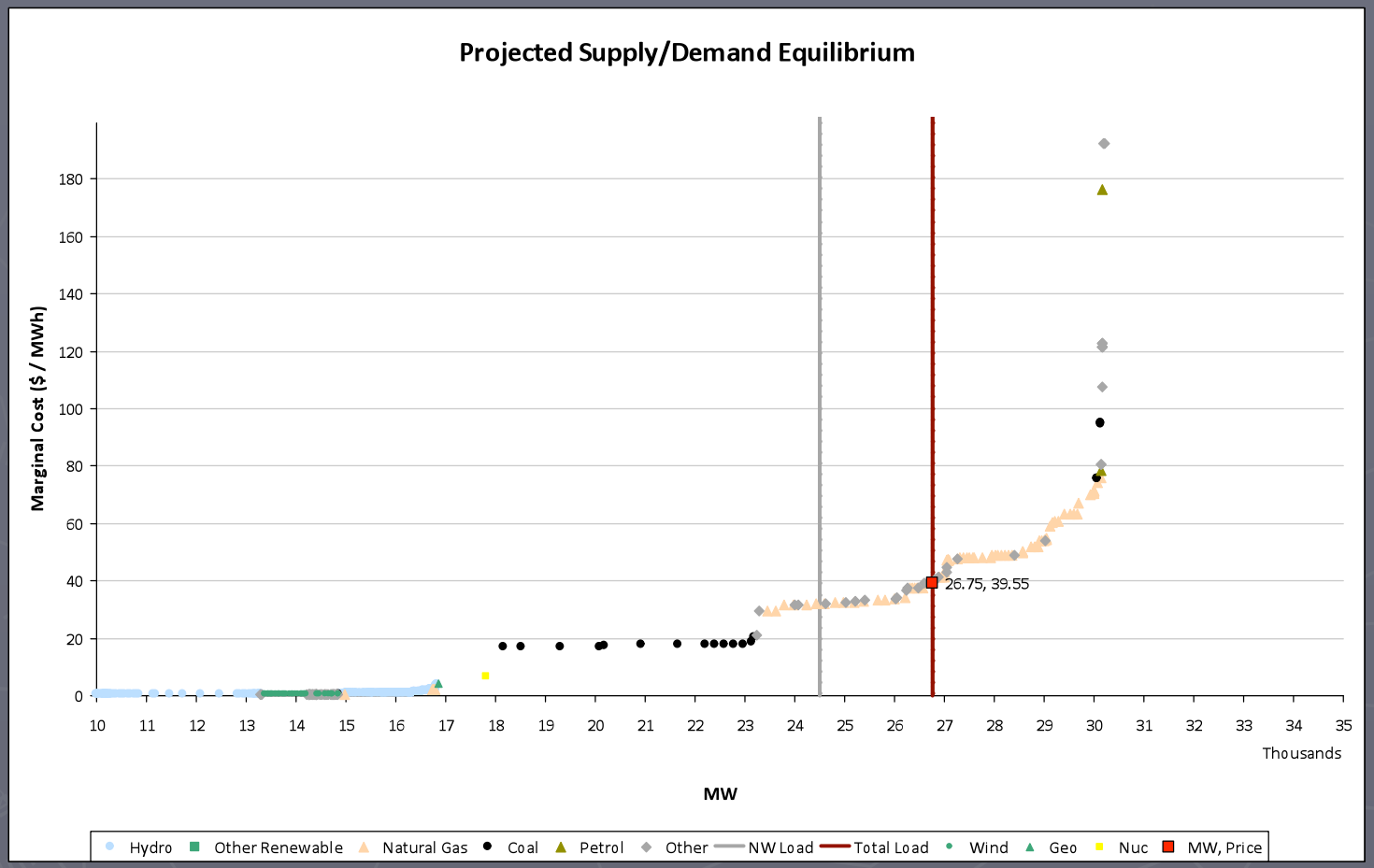
- The Intercontinental Exchange (ICE), an anonymous electronic trading platform that works something like eBay. Traders are able to submit and strike, bids and offers
- SIBR for the California ISO (similar to ICE)
- Brokers, a third party that arranges transactions for a commission
- Old fashioned phone calls between buyers and sellers

Probability Management and Hedging Risk

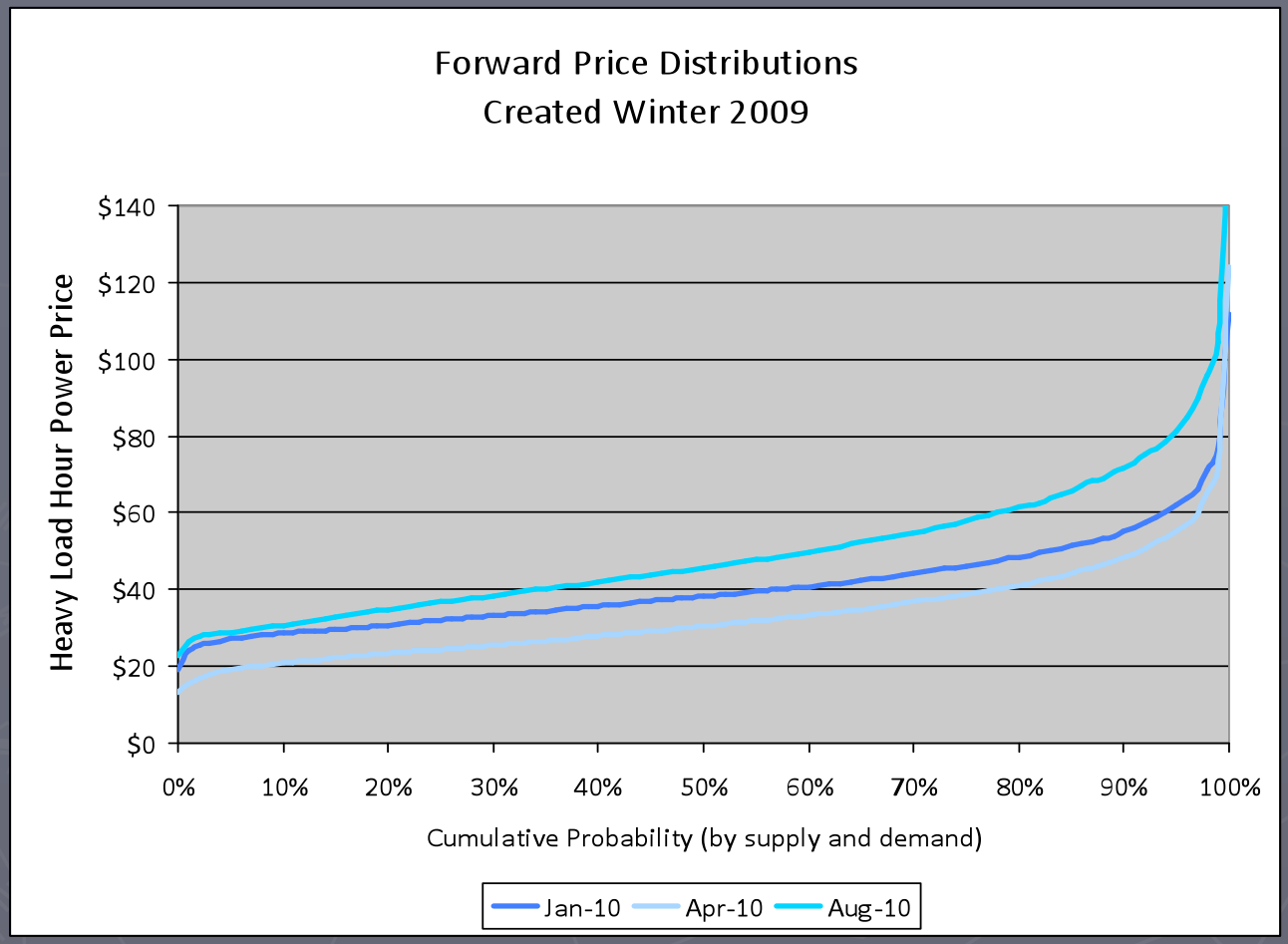
Given large amount of uncertainty in future inventory, what risks must be realized and managed?

- Market liquidity: It is unknown how much depth will exist in the balance of month, daily, and hourly markets
- Price volatility: Considering the uncertainty in natural gas prices, thermal unit outages, hydro generation, available transmission, and regional demand for electricity, future power prices are difficult to predict

Probability Management and Hedging Risk



Probability Management and Hedging Risk



Probability Management and Hedging Risk

There is a tremendous amount of uncertainty in the power business

- Streamflows, water supply, and hydro generation
- Weather and temperature departures
- Thermal generation and thermal unit outages
- Available transmission and system congestion
- Demand for energy
- Coal, natural gas, and electricity prices
- Market liquidity

Probability Management and Hedging Risk

How is all of that uncertainty managed?

- Identify the risks
- Understand the tolerance for risk
- Use the marketplace to manage the tail ends of the inventory distributions by:
  - Forward marketing to reduce the exposure to price volatility and market liquidity issues
  - Trading options for the purchase and sale of electricity